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The University of Queensland Surat Deep Aquifer Appraisal Project (UQ-SDAAP)

Scoping study for material carbon abatement via carbon capture and storage

Supplementary Detailed Report

Methane survey over Surat Basin seismic anomaly

30 April 2019

Authors

Terra Sana Consultants

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1. Summary

For a large scale CCS project, minimising containment risk is paramount. There are recorded cases of faults conducting gas from deep source rocks and reservoirs and this being associated with a “seismic anomaly”, sometime also referred to as a “gas chimney” (e.g. Loseth et al. 2009; Barthold et al. 2003). Gas chimneys are generally characterised by a disruption in seismic reflectors at many levels, often increasing in width as depth decreases and sometimes with a marked velocity “pull-down” effect. Evidence of a fault (offsets in reflection events) would support a chimney hypothesis. Absent additional data and reasoning, such a seismic anomaly itself is not ‘proof’ of vertical gas migration.

Seismic anomalies have been noted in the deep Surat Basin. The most prominent of these seismic features was investigated further in an effort to seek evidence the possibility of hydraulic communication to surface. The most detectible feature would be if the anomaly were associated with elevated methane concentrations at the surface.

The surveys described in this report did not detect elevated surface methane levels.

The hypothesis is that essentially a region of potentially enhanced permeability, perhaps associated with the faults damage zone, allows vertical methane migration and results in a characteristic anomalous seismic signature. The main anomaly is indicated on seismic line BMR84-14 displayed in Figure 1.

2. Introduction

Seismic anomalies and features that have been noted in the seismic analysis across the Surat Basin and require further investigation include geometries and indicators indicating that certain fault segments could be connecting Permian strata to the surface. Examples are highlighted in seismic lines C-11-03 and BMR84-14 (Figure 1). The seismic line BMR84-14 exhibits a strong and abrupt vertical seismic interference at the centre of the basin near the Meandarra 1 well. A first impression of this anomaly is that it could be associated with a gas chimney.

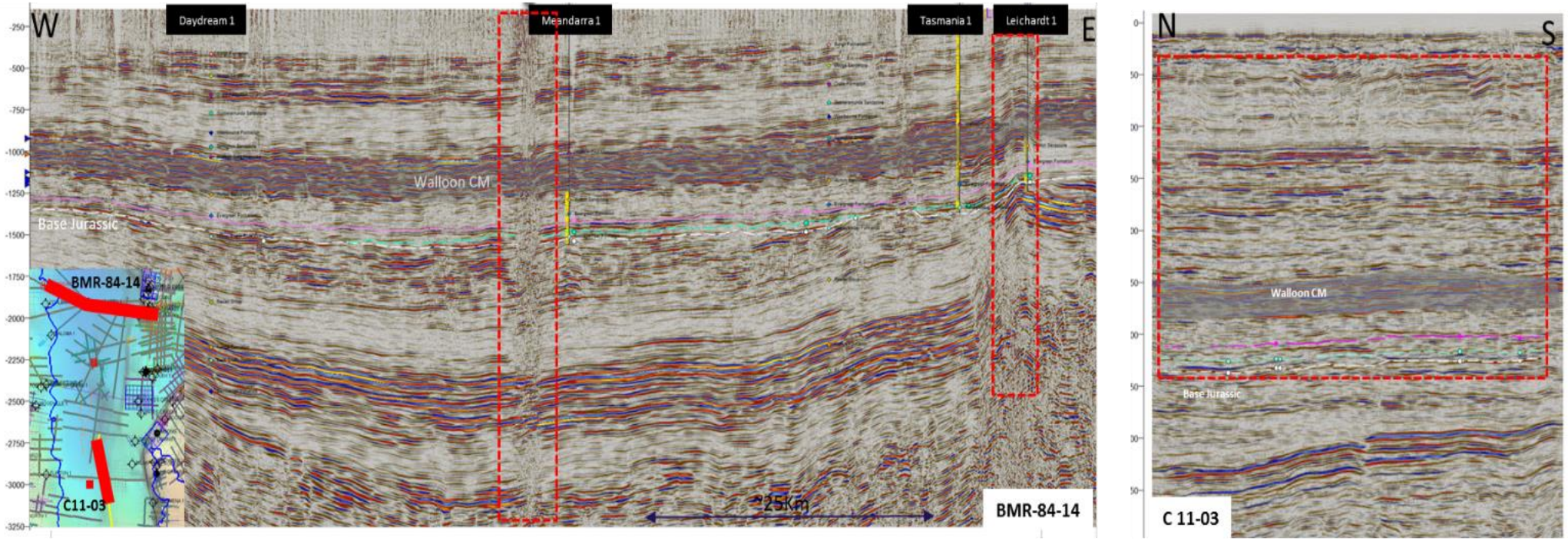
Alternatively, processing or acquisition parameters could also be an explanation, while the anomaly towards the east of the same line could be associated with reactivation of the Leichardt fault that propagates near to the surface. Further south in the seismic line C11-03, a chaotic seismic pattern near the surface could be interpreted as strain, however, it does not show roots through to the underlying units

With respect to Figure 1, as a candidate for a “gas chimney”.

- ✓ Zone of disturbed seismic reflectors extended from depth to surface.
- ✓ Apparent “pull down” in the Walloon CM reflectors
- ✓ Associated with a fault (clear reflector offset) at depth of ca. 2250 msecs TWT.
- ✓ Associated with a source rock. The reflectors at 2250 msecs are the main Permian coal measures

In this case, an anomalously high methane signature in the atmosphere, soil gas or in surface water could have corroborate if there is vertical leakage occurring or not. This would particularly be true if any detected gas were of thermogenic origin (i.e. likely generated in the Bowen Basin source rocks).

Figure 1 *Left: seismic line BMR84-14 W-E showing the vertical seismic anomalies up to the near surface in the centre and the eastern flank. Right: seismic line C11-03 N-S displaying the large number of features in the near surface along the mute seismic zone.*

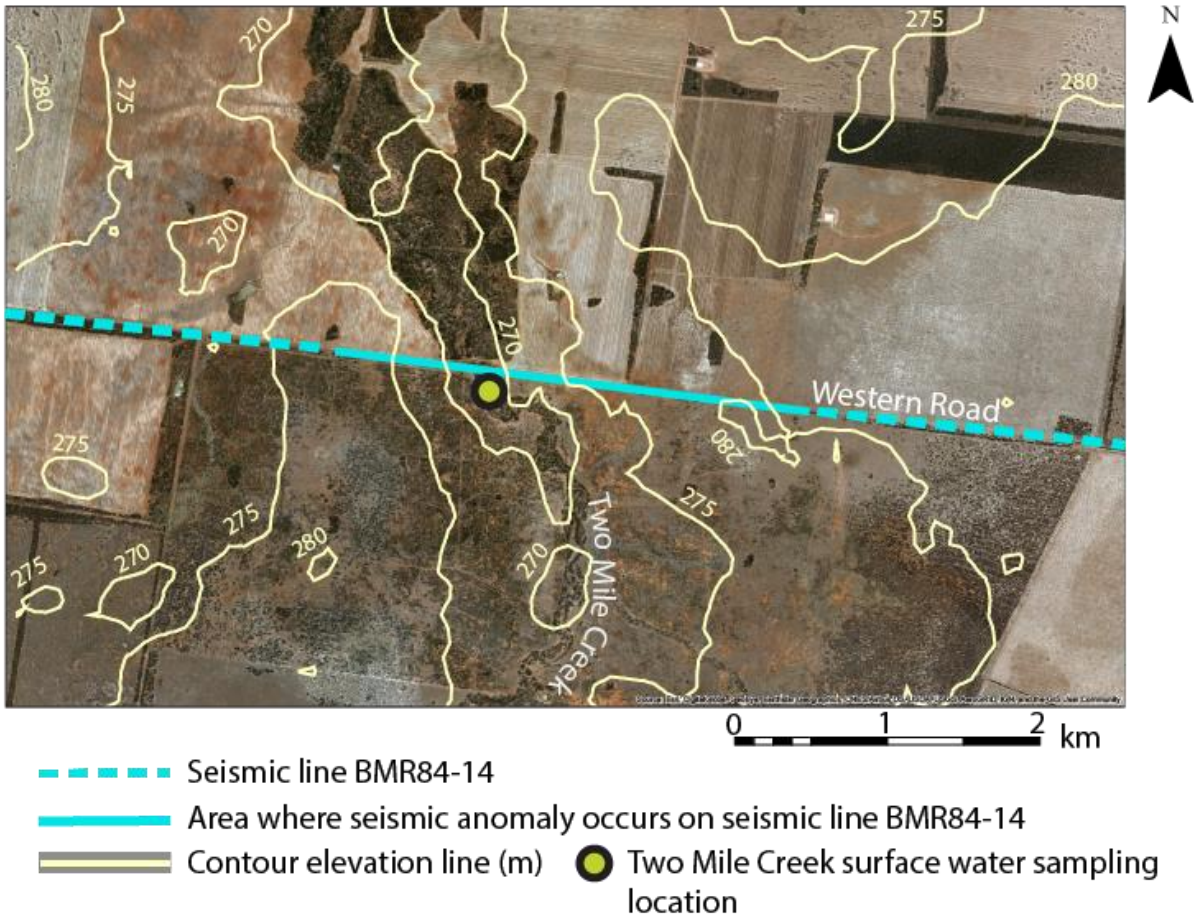


3. Seismic anomaly analysis

3.1 Site description

The main seismic anomaly coincides with approximately 2.7 km of Western Road (the road along which the line was recorded). The topography of this area is relatively flat, and the seismic anomaly intersects the upper reaches of a first order tributary of the Condamine River, Two-Mile Creek. This creek is ephemeral, and only flows intermittently during storm events. Adjacent land use is agriculture, comprising cattle and cropping, with some sparse native vegetation present. Figure 2 provides an aerial image, including contour elevation, of the study area to highlight topographical constraints.

Figure 2 Location of seismic anomaly site.



3.2 Methodology

In order to assess possible gas migration from the deep Surat, particularly the Precipice aquifer, we performed a number of atmospheric gas survey techniques in combination with dissolved hydrocarbon gas samples from a local, gassy bore and surface water sites. The target gas for these surveys was methane, although dissolved C2-C6 were also sampled at the bore site. Methane was determined as an appropriate target gas due to its ubiquity in Surat Basin aquifers, including in the Precipice aquifer. Considering this, we developed the following hypothesis:

The detection of methane plumes (laser meter surveys) in combination with measured fluxes of methane along the seismic anomaly, but absent in the control area, is evidence of subsurface methane fluxes due to site-specific geological phenomena identified by the seismic data.

In order to test that that the fluxes of any detected methane were directly associated with the identified seismic anomaly, a control site was also required. We selected a control site as property off Western Road with similar terrain but in an area not overlying the seismic anomaly.

The gas surveys consisted of two sequential methane gas survey techniques at both the seismic anomaly site and the control site:

1) Gas plume detection conducted via methane gas scanning surveys using a prototype laser detector via:
    i. Traversing a specific section of Western Road (seismic anomaly site) or track (control site) in a vehicle travelling ~10-15 km/h; and
2) At specific locations where methane gas plumes were identified in 1), flux hoods coupled to gas flux meters to determine the flux of methane over time and the concentration of different gases, respectively.

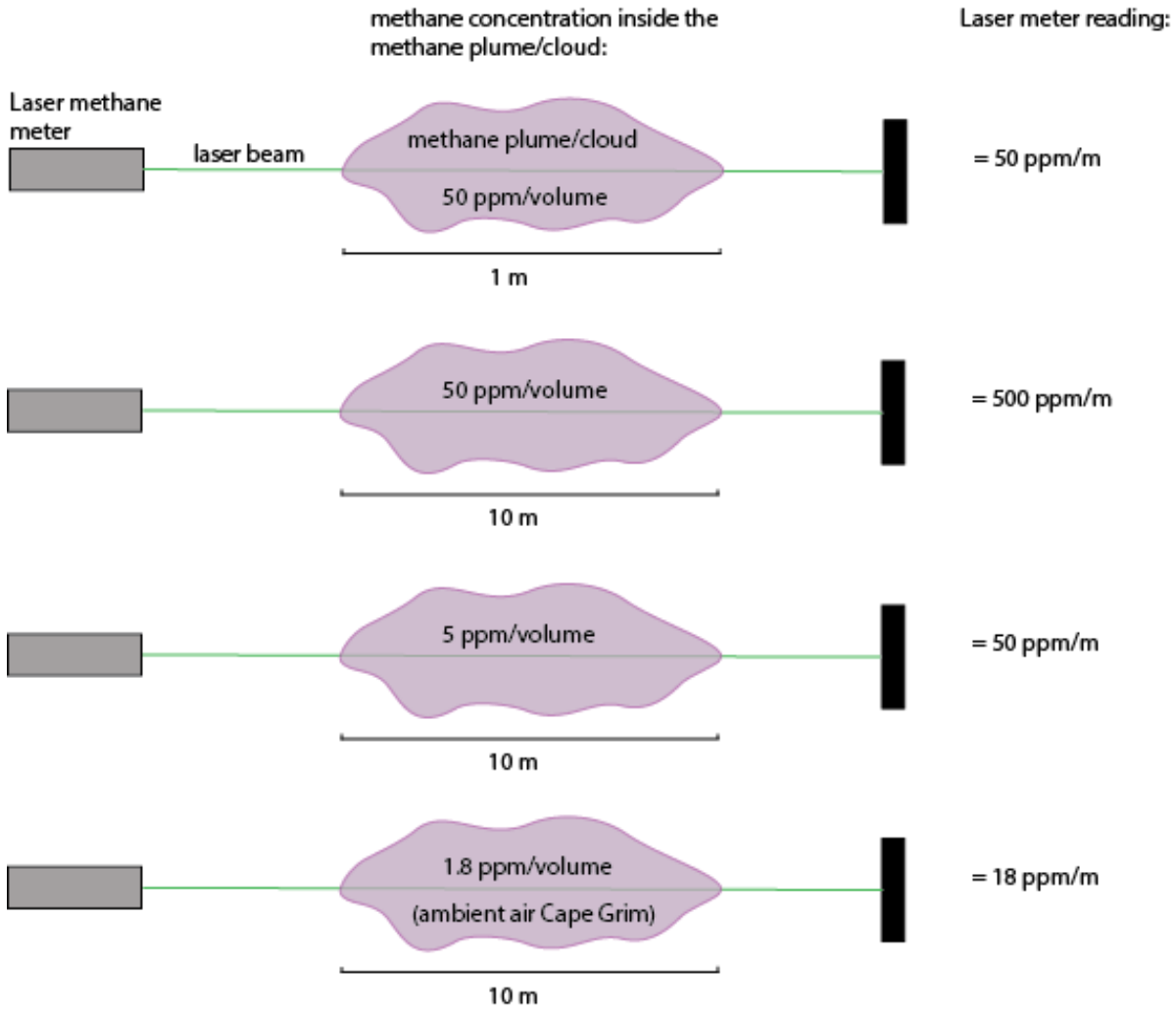
In addition to the above, a gassy bore (located at the control site, ~880 m deep and open ~800-880m) and 2 surface water sites, located at the intersection of the seismic anomaly and Two Mile Creek, were also sampled for dissolved C1-C4 hydrocarbon gases. This approach was used because methane derived from the Precipice aquifer can be associated with the presence of higher chain (C2-C4) hydrocarbons, with the gassy bore samples used as a broad indicator of deep aquifer gases. Any vertical flux of C1-C4 gases along the seismic anomaly from the subsurface would result in dissolved hydrocarbons in surface water at this site.

The methane gas surveys were conducted by Terra Sana Consultants Pty Ltd on 11 December 2018, and details of these surveys included in this report are derived from a report provided by Terra Sana to The University of Queensland on 12th February 2019. Laser methane detector data was collected using prototype open-path absorption spectroscopy detector (detection limit 1 ppm/m, detection speed 0.1 s, detection distance 0.5-100 metres) coupled with a real-time data acquisition system. Surface and groundwater sampling was conducted by the University of Queensland on 11 December 2018. Samples for dissolved hydrocarbons (C1-C4 gases) were collected by filling 40 ml glass vials with rubber butyl stoppers using a syringe, and ensuring no headspace. The C1-C4 hydrocarbon gases were analysed at the Australian Laboratory Services laboratory in Melbourne, Victoria (procedure ALS EP033-LL, detection limit = 1 µg/L).

3.3 Laser methane detection data

Laser methane sensors work by emitting a laser beam with a specific wavelength, and then measuring the reflection of a laser beam pointed at a surface. Methane will adsorb part of the beam, and this adsorption changes the reflected beam, which allows a methane measurement in the air to be made. The laser reading is dependent upon the distance that the laser beam travels through a gas cloud containing methane. Therefore, the units of data collected from laser methane detectors are always per unit of distance, e.g. metre, for example ppm/m, %Volume/m or %LEL/m. Data readings are most often presented in ppm/m, which changes due to length of the plume (Figure 3). For example, a ppm/m reading of 50 ppm can be indicative of a 1 m long methane plume (or “cloud”) with an internal methane concentration of 50 ppm/volume, or, alternatively it can be indicative of a 10 m long methane plume, with an internal methane concentration of 5 ppm/volume. As a result, the laser meter ppm/m readings will also change depending on the angle that the beam enters a plume; for example, if it is parallel to the plume length then it will be higher than if it is perpendicular to the plume length. Given this, laser methane data need to be interpreted in context, and generally are only effective at detecting possible methane plumes from point-sources following repeated stationary measurements at individual sites.

Figure 3 Conceptual representation of the effect of gas plume/cloud on raw laser methane meter data readings.



During a methane survey, a laser methane detector is used by pointing the laser beam at the ground surface and traversing a transect with the laser data continually logging. Readings below 25 ppm/m are generally considered within background limits, although higher readings (up to 500 ppm/m) may occur due to a number of factors not related to a point source methane leak, including: measurement error; dust or other interference; and the presence of multiple or diffuse sources of methane nearby. For this survey, when readings along the seismic anomaly transect were detected > 100 ppm/m, the vehicle was stopped and repeated measurements were made around the area from different angles where a high reading was detected. Under a scenario where a point-source of methane discharge was occurring, a plume of methane would be detected by the laser methane detector: this would be confirmed by repeated, stationary high ppm/m readings at the site. If repeated, stationary measurements could not be confirmed it would be concluded that a point-source plume of methane does not exist at that site.

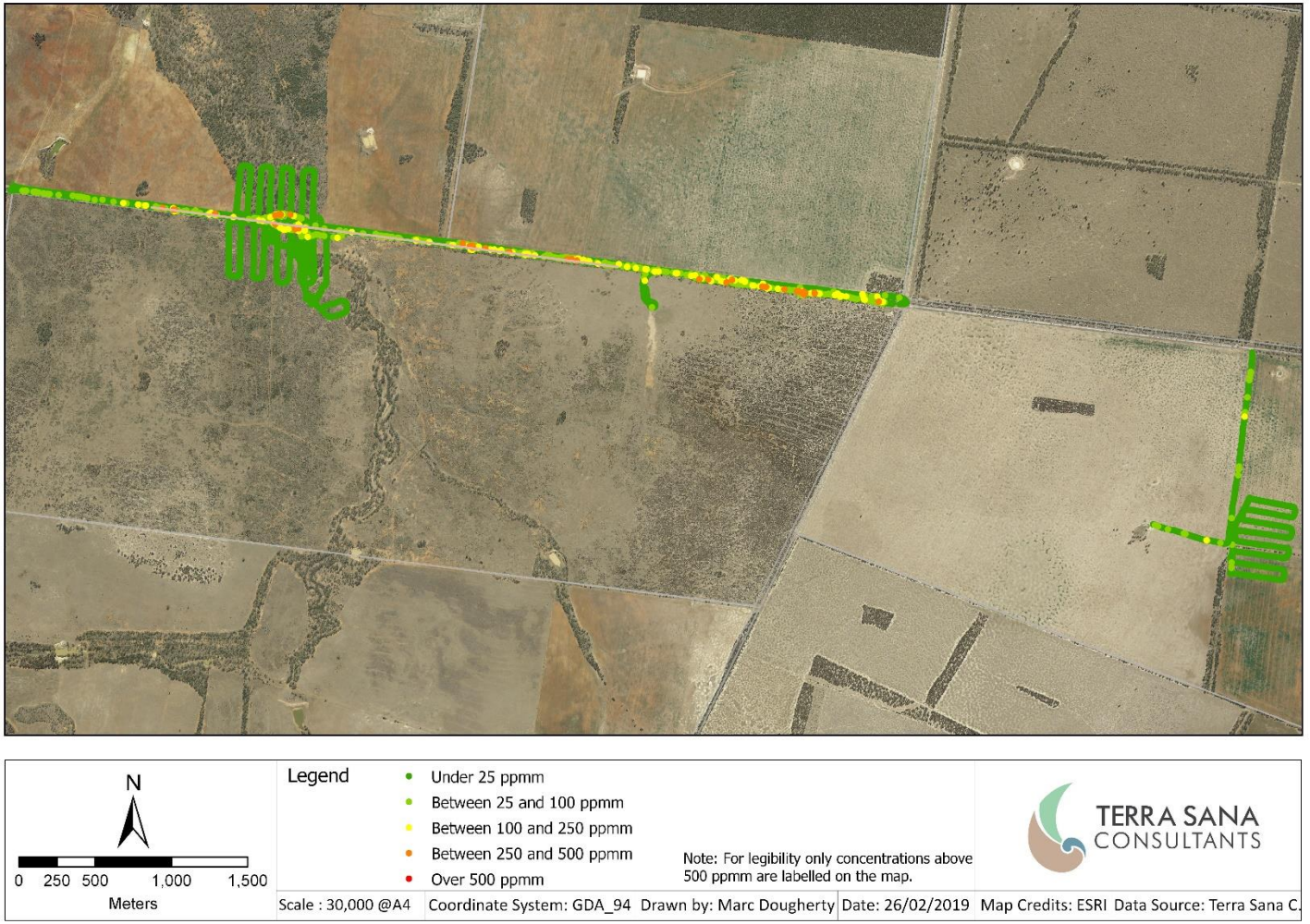
4. Results

Gas plume detection surveys using the hand held laser meter and the drone surveys did not detect methane ppm/m readings above expected background methane ppm/m readings in the area, either in the area above the seismic anomaly or at the control site (Figure 4). As a result, flux chamber measurements were not conducted.

Analysis of dissolved hydrocarbons from two surface water samples taken from standing pools at the intersection of Two Mile Creek and Western Road showed methane concentrations of 8 µg/L and 3 µg/L respectively, with no other hydrocarbons present. These low methane concentrations are most likely generated in-situ in the stagnant pools; considering the no-flow condition and the presence of cattle manure in and around the pool, these dissolved methane concentrations are unexpectedly low for these conditions.

Overall, the survey did not find evidence of gas leakage at this seismic anomaly site, confirming the null hypothesis.

Figure 4 *The following three maps are laser methane survey results from vehicle and drone survey along Western Road and upstream and downstream of Two Mile Creek, and a control area in the east.*



N

0 250 500 1,000 1,500

Meters

Legend

Methane concentrations in ppmm

- Under 25 ppmm
- Between 25 and 100 ppmm
- Between 100 and 250 ppmm
- Between 250 and 500 ppmm
- Over 500 ppmm

Note: For lisibility only concentrations above 500 ppmm are labelled on the map.

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Scale : 30,000 @A4	Coordinate System: GDA_94	Drawn by: Marc Dougherty	Date: 8/02/2019	Map Credits: ESRI	Data Source: Terra Sana C.

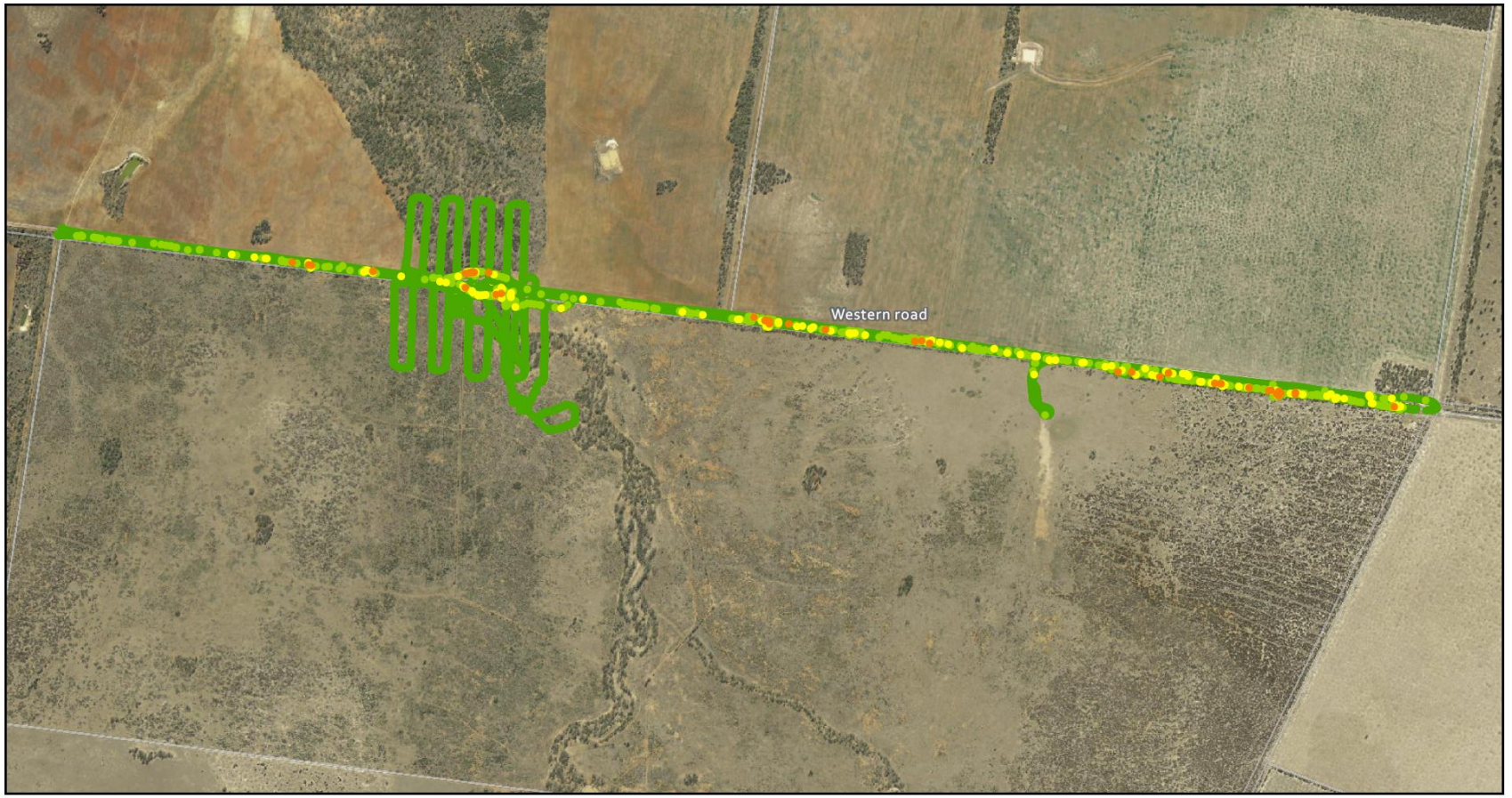

Figure 1 - Possible seismic anomaly on Western Road - Surface methane gas monitoring walk-over and drone survey

N

0 250 500 1,000

Meters

Legend

Methane concentrations in ppmm

- Under 25 ppmm
- Between 25 and 100 ppmm
- Between 100 and 250 ppmm
- Between 250 and 500 ppmm
- Over 500 ppmm

Note: For lisibility only concentrations above 500 ppmm are labelled on the map.

TERRA SANA CONSULTANTS

Scale : 22,500 @A4	Coordinate System: GDA_94	Drawn by: Marc Dougherty	Date: 8/02/2019	Map Credits: ESRI	Data Source: Terra Sana C.

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